The Institute of Physics

BULLETIN

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The Bulletin is published by The Institute of Physics for circulation to its members ; copies should not be placed in libraries.

Notices to Members

Payment of annual fees and subscriptions to periodicals for 1957

As in the past few years a subscription reminder and remittance form will be printed in the January, 1957, *Bulletin* and members are asked to make use of this form when sending in their annual fees and subscriptions for periodicals.

Institute Journals for 1957

Unless fresh instructions are given before mid-December, 1956, it will be assumed that members taking journals wish to have in 1957 the same that they had in 1956. Those who wish to cancel journals are especially asked to do so as early as possible in order to avoid the dispatch of journals unnecessarily. Members who wish to order journals for the first time are asked to do so soon to ensure prompt dispatch of the January issue.

The reduced rates for members' journals remain unchanged for Graduates, Subscribers and Students but Fellows' and Associates' rates will be as follows :

Journal	1957	1956
	£ s. d.	£ s. d.
Journal of Scientific Instruments ...	Unchanged	1 5 0
British Journal of Applied Physics ...	1 . 5 . 0	1 0 0
Both Journals ...	Unchanged	2 0 0

Publications of other Societies for 1957

Members at present subscribing to periodicals of other societies are asked to re-order as soon as possible for 1957. Individual letters are being sent to the members concerned.

Members who have not been subscribing to periodicals of other societies during 1956 but who wish to subscribe to any of them in 1957 are asked to place their orders as soon as possible. The reduced rates for periodicals of other societies are shown below.

Publications.	*Reduced Rate Per Annum*	
The Institution of Electrical Engineers :	1957	1956
Science Abstracts—	£ s. d.	£ s. d.
Physics Abstracts	Unchanged	2 0 0
Physics Abstracts (single sided) ...	,,	2 10 0
Electrical Engineering Abstracts ...	,,	2 0 0
Electrical Engineering Abstracts (single sided)	,,	2 10 0
Both sections together	,,	3 12 6
Both sections together— (single sided)	,,	4 12 6
Journal	17 6	12 6
Proceedings—part A (Power Engineering)	1 2 6	17 6
Proceedings—part B (Radio and Electronic Engineering)	1 2 6	17 6
Proceedings—part C (Monographs) ...	10 0	7 6
All three parts together with the *Journal*	3 10 0	2 10 0
The Physical Society :		
Proceedings—part A or *Proceedings*—part B (only one part may be taken)	Unchanged	2 12 6

Emolument Inquiry

There has been an excellent response to the inquiry concerning salaries and other emoluments received by Fellows, Associates and Graduates. Any members of these grades who have not returned the cards are asked to do so by November 23 at the latest.

Graduateship Examination, 1957

Candidates for the 1957 Graduateship examination should submit the required form of application not later than December 31 next. Forms may be obtained from the Deputy Secretary.

The examination will begin on June 10.

National Certificates in Applied Physics —1956 Examinations

The number of candidates for the National Certificates in Applied Physics continues to increase at a most gratifying rate. This year 424 students, from 29 colleges, took the examination for the Ordinary Certificate, or such parts of it as they were required to take. Of these, 272 were successful, 192 being entitled to the award of certificates and 80 complying with the requirements for entry to the Higher Certificate course although not eligible for the award of Ordinary Certificates. This latter group consists of candidates who hold qualifications such as the Advanced level General Certificate of Education in physics and mathematics and who complete the further requirements of applied physics, workshop practice and chemistry in a one-year course.

At the Higher Certificate level 146 candidates took the full examination and 17 others took only applied physics papers, either for endorsement or for assessment at A.1 level, as a few courses require. Certificates were awarded to 101 candidates. In individual subjects, 49 distinction marks were given, 23 in mathematics, 14 in physics, 9 in applied physics and 2 in computations (a subject of the special course for computers at Northampton Polytechnic, London). Three candidates obtained distinction in all three papers of the final examination, two from South-East London Technical College, Lewisham, and one from Swansea Technical College.

Within 1%, the proportion of passes was the same for each of the three subjects, 80% at the Ordinary level and 85% at the Higher.

The Institute's assessors were Professor

J. D. Craggs (physics), Mr. G. W. Warren (applied physics), and Dr. J. Topping (mathematics) for England and Wales, and Dr. G. Morris for all subjects in Scotland.

The growth of the number of candidates examined is shown in the following table.

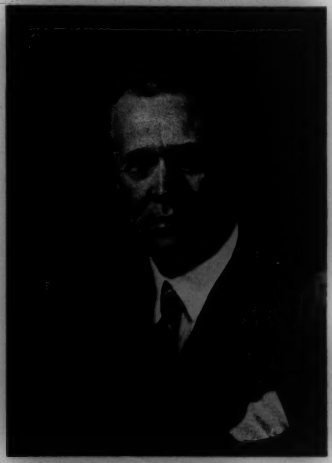
	Higher	*Ordinary*
1952 ...	33	137
1953 ...	55	151
1954 ...	75	206
1955 ...	82	309
1956 ...	146	424

NEW VICE-PRESIDENT AND ORDINARY MEMBERS OF THE BOARD

Professor Edwin Augustus Owen M.A., Sc.D., D.Sc., F.Inst.P.

The Board has appointed Professor E. A. Owen to fill a casual vacancy for a Vice-President.

Born in 1887, Professor Owen took his initial degree at the University College of North Wales, Bangor, in 1909, with Honours



in Mathematics and in Physics. He spent one additional session at Bangor as a post-graduate student conducting research under the supervision of Professor E. Taylor Jones who afterwards occupied the Kelvin Chair of Natural Philosophy at Glasgow University. Entering Trinity College, Cambridge, with an 1851 Exhibition Scholarship, Professor Owen spent from 1910 to 1912 carrying out research under the direction of Sir J. J. Thomson at the Cavendish Laboratory where he became interested in problems concerning X-ray absorption. In October, 1912, he took up a post as an Assistant in the Metrology Department of the National Physical Laboratory. Seven years later he was appointed Head of the Radiology Division of the Laboratory, a post which he held for seven years. During this period he organized and developed the work of the Division in new directions, devoting particular attention to researches on the structure of metals and alloys as revealed by X-rays. He left the National Physical Laboratory in 1926 to become the Professor of Physics at University College, Bangor, holding the Chair until his retirement in 1954. There he continued his researches on the crystal structure of metals in which field he has published many papers. He served as secretary to the International Committee for Radiological Units from the inception of the Committee in 1925 till 1937, and played a prominent part in the establishment of the "Röntgen," the unit of X-ray dosage. It is for his work in radiology and his X-ray researches on metals that he will be best known to physicists. He has also served, and is at present serving, many scientific educational and other organizations, especially in Wales.

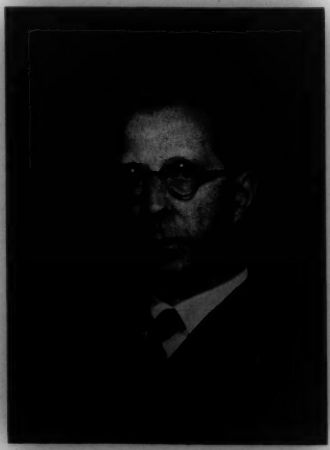
Professor Owen is a Founder Fellow of the Institute and served on the Board from 1940 to 1945. When the Liverpool and North Wales Branch of the Institute was established two years ago he was elected its first Chairman and in that capacity again became a member of the Board.

Leslie Ronald George Treloar
Ph.D., D.Sc., F.Inst.P.

Dr. Treloar is now fifty years of age and has been a Fellow of the Institute for almost twenty-three years. A graduate of the University of London, he spent two years on research in physics in the University of Reading before joining the staff of the General Electric Company Limited in 1929. His work there was concerned with valves and in particular with thermionics and secondary-electron emission. In 1938 he joined the staff of the British Rubber Producers' Research Association at Welwyn Garden City and perhaps Dr. Treloar is best known among scientists for his authoritative work on the properties of rubber. For the last few years he has been a senior member of staff of the British Rayon Research Association.

He has been President of the British Society of Rheology.

Geoffrey William Warren
M.B.E., B.Sc., F.Inst.P.



Mr. Warren, who is now 53 years old, joined the staff of the Radio Department of the National Physical Laboratory in 1924 while working for an external degree in physics at Birkbeck College. He graduated with first class honours in 1927 and a year later joined the Research Laboratories of the General Electric Co. Ltd., where he has since remained. Most of his work has been research connected with thermionic valves but he has recently taken charge of the group concerned with research in metallurgical physics.

Becoming a Fellow of the Institute in 1938, Mr. Warren has served it in several offices. For some years he was the Honorary Secretary of the Electronics Group and subsequently its Chairman. He has also served on the Committee of the Education Group, of which he recently became Chairman. The combination of Mr. Warren's industrial research experience and his interest in education have been particularly valuable to the Institute through the work he has done as the Assessor for applied physics for the Ordinary and Higher National Certificates in Applied Physics. From this office he has just retired after serving for six years. He is also on the Membership Committee as one of the two regular members of its Interviewing Panel.

Vol. 7, November, 1956

Impressions of the Geneva Conference on the Peaceful Uses of Atomic Energy*

By J. M. A. LENIHAN, M.Sc., Ph.D., A.M.I.E.E., F.Inst.P.

(*Regional Physicist, West of Scotland Hospitals*)

THE INTERNATIONAL CONFERENCE on the Peaceful Uses of Atomic Energy brought together nearly 3,000 technical experts from 70 countries for a fortnight of very hard work in the marble corridors and gilded assembly rooms of the Palais des Nations. Sixty sessions received and discussed 450 papers covering a great variety of subjects which were further illustrated in two exhibitions held at the same time.

Each participating country was allowed to send five delegates, supported by any number of advisers; the British party was drawn from the staff of the Atomic Energy Authority, with a few representatives of the Medical Research Council and of commercial firms. Suitably qualified individuals were allowed to attend as observers and nearly a thousand correspondents described the proceedings for the world's newspapers and broadcasting stations.

The scientific sessions uncovered a good deal of fresh information, made available as the result of changes in the classification rules relating to British, Canadian and American research. Russian progress in many aspects of atomic energy was also revealed for the first time.

In nuclear physics the main interest was concentrated on fission cross sections of uranium and plutonium, which have been studied independently in several countries during the last 10 years. When the results of this work were disclosed it became obvious that many of the well-kept secrets had gone stale, for the results obtained in British, American and Russian laboratories were almost identical.

Information on the design and construction of nuclear reactors, which had previously been rather restricted, was now made public for the first time and lectures were given on a number of recent British projects, including the experimental reactor at Dounreay and the heavy water reactor DIDO which is being built at Harwell.

Power reactors for the production of electrical energy came in for a lot of well-informed discussion. The three countries most deeply engaged in this work—Britain, Russia and the United States—exhibited very different approaches. In America, where ample reserves of coal and oil are available, nuclear energy is seen as an economic asset which may produce electricity more cheaply than existing methods allow. With this prospect in mind several costly prototypes are being built, mostly by engineering firms and electricity supply companies, in the hope of finding at least one power reactor scheme which will be financially attractive.

In Russia a small nuclear power station is already operating near Moscow. A water cooled reactor driven by enriched uranium produces 30 megawatts of heat, converted to 5 megawatts of electrical energy by turbo-alternators of conventional design and some-

* Based on a lecture given to the Education Group on April 5, 1956.

what old-fashioned appearance. Delegates saw an excellent colour film entitled "The First in the World" which describes the project in detail and emphasized its propaganda value. Technically, a power station of such small output and poor efficiency teaches no useful lessons and economically it is not at all attractive.

In Britain, where the primary need is for a new source of power very soon, to augment our dwindling coal production, the main effort is being concentrated on gas-cooled reactors of the Calder Hall type, using natural uranium fuel with a graphite moderator. Several stations of this unsophisticated design will make a token contribution to our power consumption during the next ten years.

The number of feasible power reactor systems is very large and the conference heard about more than twenty schemes now being prepared. Their relative merits were discussed at length but no clear guidance was produced ; obviously this is a problem for each country to tackle in the light of its own requirements and resources. Ironically enough, the countries best equipped for the exploitation of nuclear power are Russia and America, where the need is least urgent. In Britain, where an energy famine is uncomfortably near, the shortage of technical man-power and of high-grade fissile materials (such as plutonium and enriched uranium) makes the large-scale development of atomic energy much more difficult.

The biological sessions brought little that was new, though the only real controversy of the meeting arose in discussion of the genetic hazards of radiation. One British delegate submitted a paper containing the suggestion that anxiety over long-term genetic hazards might be exaggerated. Increasing the natural background would, he thought, merely speed up the evolutionary process with beneficial results through the spontaneous production of genius as well as the much-advertised harmful consequences. These remarks were not well received by the geneticists and were forcefully repudiated ; the exchanges would have been even hotter but for the procedural rules restricting extemporary discussion. The same rules were invoked during a later session when Professor H. J. Muller was prevented from speaking on a subject peculiarly his own—the production of mutations by radiation. Eventually the frustrated audience of delegates, led by the chairman, gave him a standing ovation.

The medical applications of radioactive isotopes have nourished so many conferences in recent years that there was very little fresh work to be reported at Geneva. The papers that were presented included a great many general surveys and only a few dealing for the first time with individual pieces of original investigation.

An interesting topic which generated a lot of excitement, though it did not appear in the official programme, was the extraction of energy from fusion processes in hydrogen and other light elements. Dr. H. J. Bhabha, in his presidential address on the first day of the conference, predicted that a method would be found for liberating fusion energy in a controlled manner within the next two decades. Few people were prepared for this speculation, least of all the newspaper correspondents, who harassed the heads of delegations, quite politely and ineffectively, for several days, after which the excitement passed off. It soon became known that work on fusion reactions was going forward in several countries, but no one would say anything about it officially.

Two large exhibitions were held during the period of the conference. The first, occupying odd corners in the Palais des Nations, was provided by several of the participating countries who displayed models and photographs illustrating their own atomic energy projects. The two highlights were the Russian exhibit and the swimming pool reactor built by the Americans. A handsome wooden building in chalet style was erected in the grounds of the Palais to contain the reactor with its controls, and a spectator's gallery, to which the general public were admitted in large numbers. The fuel core, of enriched uranium in an aluminium lattice, was clearly visible under 16 feet of highly purified water and glowed

with a soft blue light (from Cerenkov radiation). The reactor was afterwards sold to the Swiss government at a bargain price.

A larger and more lively commercial exhibition was mounted in the Palais des Expositions at the other side of the city. Here some 150 manufacturers laid out their wares for the inspection of the delegates and the townsfolk. The British had the best of this show. The Atomic Energy Authority produced a handsome collection of equipment, models and information with a large staff of demonstrators. A smaller exhibit was provided with all its captions and literature in French—a delightful gesture much appreciated by the citizens of Geneva.

British engineering firms, profiting by their close co-operation with the Atomic Energy Authority, were able to offer quite detailed schemes for reactors and auxiliary equipment. Several American firms were concerned with the same sort of merchandise, though no customers were to be seen.

Everyone who attended the conference must have been asked on his return "What about the Russians?" The large Russian delegation took a full part in the meeting and read about 70 papers. The most interesting were those describing the six nuclear reactors built since 1947, using an apparently plentiful supply of enriched uranium. All are of quite straightforward design and one has been working since 1952 at the very high neutron flux of 8×10^{13} n/sq. cm/sec.

The Russians added their findings to the store of nuclear information needed for reactor design; where comparisons could be made their figures were almost identical with those found in Britain and America. On other topics the Russian papers were sound but not remarkable.

Individually the Russian delegates were friendly, but informal technical discussions were not very successful. Some people suspected unwillingness to reveal essential pieces of information and others attributed this reticence to language difficulties. Many of the delegates spoke English with difficulty and some of the interpreters had little technical knowledge.

The Russian section in the scientific exhibition contained a variety of conventional apparatus. Geiger tubes, counting circuits, thickness gauges and radiographic equipment appeared to be well designed, though more recent innovations such as scintillation counters, photomultipliers and dekatron tubes were not much in evidence. It appeared that elegance of design had been sacrificed to obtain rapid production in large quantities. Isotope techniques of a relatively simple kind are extensively used in Russian science and medicine and many of the papers describing them were concerned more with the wide scope of the operations than with their technical novelty.

The success of the Geneva conference was to some extent fortuitous, for it depended largely on the 1954 revision of the classification rules; once these changes had been made, the release of a vast amount of information became possible. We must admire the political wisdom which arranged its dissemination with excellent publicity under the auspices of the United Nations, thereby helping in a very real way to promote the advancement of learning and the freedom of science.

The reader may like to know something of the circumstances in which these threadbare reminiscences came to be written. It is hardly necessary to explain that I was not qualified to attend the conference as a delegate or an expert observer. A couple of weeks before the meeting began, the editor of a highly respectable morning newspaper to which I sometimes contribute asked me to describe the proceedings for his readers. He offered, with great civility, to defray every expense and to pay at the usual rate for whatever I might write. I cheerfully accepted this assignment, little knowing how difficult and exhausting it would prove to be.

My neighbour on the journey to Geneva was an earnest young man smoking a big cigar and studying, without much enthusiasm, a little book on atomic energy. In conversation I found that he was Bill Sexton, from the London office of the United

Press of America. He was going to the conference with some anxiety lest his technical knowledge should not be adequate ; we decided to pool our resources and in this way saved a lot of work.

The reporting of the conference was not done in the obvious way, by listening to what was said and then writing about it. This simple approach was not practicable, partly because meetings were held simultaneously in different parts of the building and partly because none of us knew enough about the subjects under discussion to produce an acceptable summary at first hearing. For these reasons, the first task after breakfast was to collect a ration of documents. Texts of the conference papers, printed in advance for issue to delegates and reporters, were doled out reluctantly by their custodian, a formidable Swiss lady, at 9 every morning. Other literature prepared by the secretariat and by the various national delegations was also available in profuse quantities.

After a study of the English newspapers, to see what their representatives had written on the previous night, the morning was spent in reading the advance copies of the day's proceedings, with occasional visits to the lecture rooms for some particularly interesting paper or discussion. The afternoon was devoted to writing a despatch of about one and a half columns, or 1,500 words, representing three hours' work at the best speed that I could achieve. There was no quiet place for meditation and composition—a deficiency which did not trouble expert journalists, though I found it very trying. Most people worked in a huge press room on the fifth floor of the Palais des Nations which gave an unpleasant foretaste of hell. Several hundred typewriters were in action all through the day, their intermittent pounding contributing to the general atmosphere of anxiety and tension. Crumpled paper littered the floor, stale smoke flavoured the air and a row of loud speakers shouted from the wall, until someone discovered how to disconnect them.

Preparing the day's report was a considerable task. I chose two or three subjects arising out of the scientific sessions or exhibitions and wrote a piece about each of them. The practised journalists were able to do this sort of thing very neatly and quickly, but I found that 500 words an hour was as fast as the words would go on to the paper without repetitions and awkward constructions. Writing with one eye on the clock is not pleasant, but a strict time-table was essential. The first edition of the paper went to press at 8.45 p.m. in order to catch the night trains and my offering had to reach the office by 7.30 p.m. for the attention of the sub-editors before it was ready to print. Most of the newspapers represented at the conference made use of public or private teleprinter lines for collecting their stories, but mine relied on the old-fashioned telephone. A call came through every day at 6.30 p.m. and I spent an hour or so in a cubicle dictating to a typist at the other end.

The journalist's life needs a tough constitution and I was worn out after my short stay in Geneva. When I returned and saw the editor again I tried to describe the unexpected weariness, frustration and chaos that I had encountered in his service. " Yes," he said sympathetically " it's always like that—but I didn't want to discourage you before you went."

Vol. 7, November, 1956

Atomic and Nuclear Physics in an Industrial Research Laboratory*

By D. R. CHICK, M.Sc., M.I.E.E., F.Inst.P.

(Research Laboratory, Associated Electrical Industries Ltd., Aldermaston)

I HAVE BEEN asked to discuss the type of knowledge and training that would be expected, and the use that might be made of graduates in atomic and nuclear physics by a present day industrial research establishment. Rather than attempting to rank the different parts of the university curriculum in relative importance, I thought that you could gain a better overall picture if I sketched the history and some of the problems encountered by a research team set up in 1947, specifically to provide a group knowledgeable in the field of nuclear physics and capable of advising an industry on matters relating to nuclear energy. Although in the last twelve months this unit has been much concerned with the design of a small research reactor, in 1947, at its formation, the only entry to the subject appeared to be by carrying out an academic programme of research in nuclear physics. This team, comprising some 50 staff, operates as part of one of the four main research laboratories which together comprise the research facilities of the A.E.I. Partly because of its objective, namely the education of industry into the possibilities and methods of a relatively new subject, the team was for some few years in a rather unusual position in the research organization. In particular, unlike most other groups within the laboratory at Aldermaston, we were not stimulated by questions and queries arising from various of the engineering and development departments. I mention this since this lack of background has some bearing on the programmes undertaken and hence in the make-up of the staff concerned. While I feel it would be dangerous to generalize too much on the basis of our experience, I feel that with the entry of industry into nuclear energy, the pattern of the team might well become more familiar in the next few years.

Mostly from the point of view of economics it was decided to carry out a nuclear study of the lighter elements in the low energy range. We quickly found that we should have to design and build our own Van de Graaff accelerator for this purpose. Even to-day, with most of this design work behind us, the staff of fifteen physicists, of whom ten are specializing in the subject of nuclear physics, require a supporting staff of some thirty-five. Of the thirty-five, ten are qualified engineers, the remaining twenty-five falling into a class of research assistant, a reasonable number of whom are Associates of The Institute of Physics. It is to be remembered that this team is backed by considerable drawing office and manufacturing effort centralized within the laboratory and of course for larger equipment a call can be made on the manufacturing facilities of the main companies. Taking into account these latter services we find we are using perhaps three members of staff to support each physicist carrying through a research programme, and from a detailed study of many individual research programmes it is my opinion that an overall improvement in efficiency would result from increasing this number to four or even five.

The necessity of designing and building our own equipment while still considering the experimental programme allowed us to include some improvements in equipment but

* A lecture given to the Education Group of the Institute on April 5, 1956

forced us to take an interest in the subjects fringing on nuclear physics. It seemed worth while, therefore, to institute a set of courses, in all cases given by members of the staff, and they were planned as a mixture of refresher and postgraduate course. As common to all interests, several courses were given in different topics of mathematics and they started by a general review of the method of determinants, revised partial differentiation and the use of multiple integrals. A subsequent series of some fifteen one-hour lectures was given on the theory of functions of complex variables, which was followed by a similar series on vector analysis discussing matrix elements and giving an introduction to tensors. A similar series was given on wave mechanics, deriving a logical development of Schrödinger's equation and introducing the concept of spin using Pauli's treatment.

In the experimental field it became obvious that the twin subjects of vacuum physics and electronics were of major importance and a 20-hour series was given on the background of electronic circuitry discussing in detail the properties of the most used networks, including a discussion of closed feedback loops and a general introduction to the wider problems of servo-mechanisms. This particular course has since been repeated and slightly extended to cover the main features of radio frequency techniques and the properties of waveguides. At the same time about twenty one-hour lectures were given covering pretty well the subject matter for final years Honours course in nuclear physics, although particular attention was paid to the experimental side of detection methods. These lectures were attended by an audience of perhaps thirty, comprising all graduates within the group and several of the more senior assistants. On many occasions, and in particular on the mathematical series, there was a fair attendance from other sections within the laboratory.

Since we were planning to enter a field in which the accuracy of measurement was of paramount importance we felt that one of the improvements which we might be able to make for our proposed Van de Graaff accelerator was in the instrumentation. The formation, focusing and energy measurement of the ion beam is a typical problem encountered in particle accelerator work; the problem is to create requisite current of charged ions with the minimum number of ions of different e/m ratio and with a minimum number of neutral atoms, to extract the wanted ions from a sensibly defined cathode region, and to be able to focus the extracted ions without modifying the number extracted or without modifying the value of the main accelerating field. Thus we have already called on a knowledge of radio frequency and vacuum techniques and some familiarity with atomic physics to produce our ions and we have had to appeal quite heavily to mathematics and perhaps numerical methods to determine the trajectory of our particles down the main discharge tube. Our parallel beam of accelerated ions must next be energy analysed and we decided to do this by using a radial electric field which allowed us the possibility of making our energy measurement absolute, determined only by geometrical parameters and a standard cell. By suitable choice of the geometry of the analyser bars, the beam parallel at entry can be focused to a line at the exit slits and if the potential across the bars is maintained to a high degree of stability only particles of the required energy will pass through the slits which are some 0·006 in. wide to hit the target. We have already appealed to the electronic engineers to maintain and measure the voltage on the analyser bars to an accuracy of three parts in ten thousand. In conjunction with the physicists, they have gone on to consider the whole machine as a servo mechanism, arranging for any error in the beam position due to an energy error to correct itself ; the basic problem being to ensure that the servo loop is both stable and fast acting. By measurement of the variation in target current when passing through the analysers we are able to conclude that the servo loop is in fact holding the generator constant to better than one part in ten thousand.

The central problem of the electrostatic accelerator remains the physics of vacuum breakdown over long gaps and with poten-

tials over 2 MV, the detailed mechanism is not understood and experimental work is difficult, costly, and no methodical attack has been launched. The problem may well be strongly modified in the presence of high energy ions scattered from our beam, but even with no source at all the behaviour of the discharge tube is complex. An example of one effect might illustrate this difficulty.

With a pressurized electrostatic generator it is not possible to achieve the full potential of the machine when the vacuum tube is installed. For many years conduction currents in the tube loading the generator were blamed as the sole reason for this effect. By considering the physics of the system in some detail and using improved instrumentation, we were able to show that the effect was due to quite small electron currents in the tube giving rise to hard X-rays at the anode, which X-rays were in fact ionizing the pressurized insulating gas around the machine, the ions so created being swept by the machine field to form a radial current perhaps five times as much as the electron current in the vacuum tube; thus the whole generator was acting as a pressurized ion chamber. The behaviour of the radial current as a function of gas pressure fitted in with this theory and by measuring the radial current we were able to achieve a satisfactory current balance around the machine.

I should like to give a few examples of the experimental work being undertaken with the accelerator in order to give you some idea of the background knowledge and techniques which will be needed in this work.

First is the simplest form of (p, γ) type of reaction, in which we are concerned with plotting the energy levels in the compound nuclei. These are determined by detecting the " resonance peak " in the γ-ray yield as the proton energy is varied, a typical example being the reaction F^{19} (p$\alpha\gamma$) O^{16}. This reaction has been studied by us with proton energies of up to 2·8 MeV and several new small resonances have been found. The errors in positioning the levels in the compound nucleus arise from loss of energy of the beam at the target, and hence the work calls for techniques requiring very thin targets, and also from the statistical errors in the counting. Geiger Müller detectors can be used for this work, but the scintillation detector is more sensitive.

Secondly, the experimental value of the work can be greatly extended if we can measure at the same time the energy as well as the number of γ-rays coming from a given state in the compound nucleus which we have excited. Such results will allow us to determine the position of excited levels nearer the ground state of our compound nucleus and will allow us to estimate the relative probabilities of the compound nucleus reaching its ground state by the several various methods. If we know the spin and parity of the initial or final state of the scheme, these branching ratios allow us to assign spin and parity to intermediate states. A particular reaction is O^{16} (d, p) O^{17*} with a value Q + 1·918.

It is known that excited states exist in O^{17} at 0·872, 3·06, 3·85 and 4·56 MeV. If we first excite the 3·85 level we would expect γ-rays of energy 3·85, 3·06, 2·98, 2·19, 0·87 and 0·79 MeV, whereas by exciting the 3·06 level we would expect γ-ray energies at 3·06, 2·9 and 0·87 MeV.

The equipment which allows us to carry out this sort of measurement, analysing the relative number of γ-rays within each energy group, is a nice example covering the fields of atomic and nuclear physics. A crystal such as sodium iodide can be made to convert the γ-ray into light and if the crystal is large enough, the light output is nearly linearly proportional to the γ-ray energy. For understanding this we need a fairly full knowledge of mechanisms of interaction between radiation and matter, and in particular, if our crystal is not large, the conversion is not complete and we must sort out the effects of the separate interaction mechanisms.

Atomic physics provides some understanding of the spectrum of the light produced and the speed of decay or relaxation time which is a most important feature if we are interested in very small time resolutions.

The light from the crystal falls on the cathode of a photomultiplier and knowledge of the photo-electric effect is called for.

Photo-electrons produced from the cathode are amplified by secondary electron processes at each dynode. Experimentally we need to understand the relations between the overall gain and the dynode potential, and to know how to stabilize these potentials. It is also necessary to realize that there is a limit to the gain that can be achieved coming both from space charge effects in the electron stream and from noise. Finally, having achieved electron pulses which are proportional to γ-ray energy, we are in need of our electronic circuit engineer to provide a device which can count and sort these pulses extremely rapidly.

We are also interested in reactions in which there is an emitted charged particle. In this sort of experiment we wish to determine the kinetics of the reaction accurately, measuring energy of the incident and emitted particle and further measuring how the probability of the reaction depends on the angle at which the particle is emitted. This form of experimental work calls for a knowledge of reaction kinetics.

Fowler showed that by suitably shaping a magnet pole face, particles of a given energy from a point source could be focused to second order in one plane; further particles of different energy would be focused to different points lying on a straight line.

Such a magnet capable of focusing 16 MeV protons and weighing five tons has been built and its magnetic field can be set and measured to 1 : 1000 by means of nuclear magnetic resonance. Further the whole magnet can be rotated about a vertical axis through the target, thus the angular distribution of the reaction can be determined. This again requires a knowledge of vacuum and target techniques together with a fair knowledge of the possible nuclear experiments, and an understanding of the statistics of counting, and also sufficient understanding to interpret the angular distribution results obtained.

In both cases these experiments should be extended in such a way that events occurring in time coincidence can be obtained. Before carrying the work to this stage, however, it was found necessary to present a further course of about twenty hours on statistics, in particular on the problems of statistical counting of random events. Two additional physics courses were also given about this time, one in the subject of statistical mechanics and one in reactor physics. The first arose because of an increase in the importance of the research in electrical discharges in gases. Statistical mechanics plays a major part in the theory of this subject, whereas the techniques of spectroscopy form a major experimental requirement.

Both in pursuing his own research work and increasingly as an adviser to other users, it is important for the physicist to be firmly based in the subject of radiation physics. This fundamentally requires an understanding of the laws of radio-activity with some concepts of the different biological effects on the human body. The subject is unnecessarily complicated by many misnamed units, and the student is well advised to think in terms of ergs/gramme as a unit for radiation work and ergs/cm^2/sec or watts/cm^2 for intensities. It will, therefore, frequently be necessary for the physicist to handle the equipment and calculations involved in ensuring that any source can be used by other workers. Factually this means that for whole body γ radiation of energies up to 3 MeV the weekly dose must not exceed 20 ergs/gramme or 0·3 r, whereas a tolerance dose for the thermal neutrons is some 2000 / sq. cm / sec and for fast neutrons 40/sq. cm/sec. For instance, in the unit concerned there are some sixty N.P.L. film badges issued for each interval of a fortnight and ninety-six blood counts are taken during the course of the year.

In order to provide research facilities in neutron physics and to some extent in metallurgy, it was felt that A.E.I. needed to have within its own control a small reactor as a research tool. This was intended primarily as training for our own staff and as a means of allowing industry as a whole to become familiar with reactors in the flesh; at the same time, it is planned to work in close collaboration with several universities and to make available training facilities to them.

From an outline design presented by the Harwell Reactor Engineering Division, members of Aldermaston laboratory have developed a light water moderated and cooled reactor for research purposes. Merlin, as the reactor has been named, uses 20% enriched uranium and is rated at 1 MW mean power with the possibility of running at 5 MW if fuel supplies allow. The fuel is a uranium oxide - aluminium mix sheathed between aluminium plates. The critical mass of the core with the reactor in a typical operating state is estimated to be about 4·5 kgm.U^{235}.

The design study of this plant has in fact been a most valuable exercise. As you will realize, many fields of physics and engineering are involved, and for the first time one can begin to see how from such a team a real knowledge and feeling for the subject can begin to grow through industry.

The physicists concerned, working with Harwell staff, have re-assessed the core calculations using two group neutron theory, resulting in the determination of the critical mass and an estimate of the neutron flux distribution. These calculations have been done on the basis of a homogeneous model, and it will be necessary to carry out " criticality " experiments to check them in due course, also to check the effect of the control rods.

In order to handle such problems a large part of the physics material as given by the A.E.R.E. Reactor School has been needed, and with this, a physics study of the proposed core has been carried out, taking into account the effects that might be expected from changes in the reflector, for instance, due to opening or closing experimental ports, moving the core, the changes of temperature of the moderator, the effect of xenon poisoning, and estimates of fuel burn-up.

From this an estimate of the built-in reactivity has been made which, for the power figures given above, would be some 5·3%. This includes a figure of 1·5% to permit absorbing material to be placed in the central experimental hole to carry out metallurgical experiments.

Thus, the total requirements for built-in reactivity are given in the table below.

TABLE I.

Reactivity $\simeq k_{eff} - 1$	
Temperature	0·28%
Experimental absorbers ...	1·50%
Xenon, 5 MW continuous	3·00%
Samarium	0·10%
Fuel burn-up, 50 MWD...	0·33%
Other fission products ...	0·08%
Core over required size...	0·08%
TOTAL ...	5·30%

The maximum radiation fluxes available are of the order :

thermal neutrons ...	$4 \times 10^{13} cm^{-2} sec$
epithermal neutrons	$2 \times 10^{14} cm^{-2} sec$
γ-rays	4×10^{8} rad/hr.

The biological shield has been designed to give quarter tolerance radiation level in the laboratory, and there are two working positions for the reactor core. The lower one allows two large graphite thermal columns to be used together with one 12 in. dia. beam hole and three 6 in. dia. beam holes, the second position allows four 6 in. dia. beam holes and two 6 in. dia. "rabbit" tubes to be used. Additionally a shelf has been arranged near the second position to allow an object up to 2 ft. cube to be brought near to the core.

The safety and control system of the reactor has been worked out in full detail in such a way as to allow manual start-up and automatic control at the required power level. Six ion chambers and one fission chamber are used to detect the neutron flux level and to give an indication of power, log power, and pile period while the circuits are arranged to fail safe such that a fault indication from any one of the six ion chambers will shut down the reactor.

In spite of the protection afforded by such a system, it has been necessary to consider the situation assuming a fuel element to have melted. The proposed reactivity conditions have been carefully compared with the experiments known as " Borax " carried out by the Argonne National Laboratory; from this comparison, we can conclude that sudden insertion of 1·75% reactivity would cause a fuel element melt. The only way in which a change of reactivity in excess of this can

occur is by a deliberate removal of the coarse control rod. Assuming an arbitrary operating programme covering a period of four years, the fission product activity corresponding to that programme has been calculated, and by 1961 this activity will have reached some 700 kilocuries. From this estimates have been made following Marley, for the hazard which might be involved in an incident in which either 100% or only 1% of the fission products escape.

As an example, with a 1% release in fission products after four years' operation temporary evacuation might be required for a range of up to one mile.

With some 8,000 population within a radius of 2·5 miles of the reactor, we are thus forced to consider the necessity of containing the reactor such that an incident of the type I have described would not represent a serious hazard. This will probably mean ensuring that only 0·1% of the fission products can escape.

By taking some of the problems with which we have been confronted, I have tried to indicate to you the background and the basic science required by the staff of such a team. In general, apart from a solid foundation in basic nuclear physics it seems to me that there is always a need for increased mathematical ability, and on the experimental side, some considerable familiarity is needed with the subjects of vacuum physics, electronics and perhaps metallurgy. The subject of heat transfer is becoming more important particularly in the reactor field and there are many aspects of the phenomena of boiling which are vitally important to reactor design.

Forthcoming Institute Meetings

Nov. 21 London and Home Counties Branch — At the Institute's House, 6.30 p.m.
"*The Design of Modern Digital Computers*"
DR. A. D. BOOTH, F.Inst.P.
(Birkbeck College, London)
Tea will be served at 6 p.m.

Nov. 22 North-Eastern Branch — At King's College, Newcastle-upon-Tyne, 6.15 p.m.
"*Vibration Research in Turbo-Machinery*"
DR. O. P. T. KANTOROWICZ, F.Inst.P.
(Pametrada Research Station, Wallsend)
Tea will be served at 5.30 p.m.

Nov. 26 Scottish Branch
In the Natural Philosophy Department, University of Edinburgh, 7.15 p.m.
"*Non-numerical applications of Digital Calculating Machines*"
DR. A. D. BOOTH, F.Inst.P.
(Birkbeck College, London)

Nov. 27 Scottish Branch
In the Natural Philosophy Department, University of Glasgow, 7.15 p.m.
"*Non-numerical applications of Digital Calculating Machines*"
DR. A. D. BOOTH, F.Inst.P.
(Birkbeck College, London)

Nov. 28 Yorkshire Branch
In the Physics Department, University of Sheffield, 4 p.m.
" *The Production of Images of Chemical Molecules* "
PROFESSOR H. LIPSON, F.Inst.P.
(College of Technology, Manchester)

Dec. 7 South Wales Branch At the University College, Swansea, 5.15 p.m.
Annual General Meeting
followed by
" *Why is it dark at night ?* "
PROFESSOR H. BONDI
(King's College, London)
Tea will be served at 4.30 p.m.

Dec. 11 Midland Branch
Visit to British Railways Research Department, Derby.
(Numbers limited ; details will be circulated to Branch members)

Dec. 11 Electronics Group At the Institute's House, 5.30 p.m.
" *Glow to Arc Transitions* "
DR. H. EDELS
(University of Liverpool)
Tea will be served at 5 p.m.

Dec. 12 London and Home Counties Branch At the Institute's House, 6.30 p.m.
" *The Preparation and Testing of Diffraction Gratings* "
DR. L. A. SAYCE, F.Inst.P.
(National Physical Laboratory, Teddington)
Tea will be served at 6 p.m.

Dec. 13 Education Group At the Institute's House, 6 p.m.
" *Postgraduate work in Universities* "
PROFESSOR N. F. MOTT, F.Inst.P., F.R.S.
(University of Cambridge)
Tea will be served at 5.30 p.m.

Dec. 14 Liverpool and North Wales Branch
In the Department of Electrical Engineering, University of Liverpool, 7 p.m.
" *Fast Nuclear Reactors* "
DR. L. R. SHEPHERD, A.Inst.P.
(Atomic Energy Research Establishment, Harwell)
Tea will be served at 6.30 p.m.

Dec. 14 Manchester and District Branch
In the Bragg Building, University of Manchester, 6.45 p.m.
" *Electroluminescence and light amplification by phosphors* "
PROFESSOR G. F. J. GARLICK, F.Inst.P.
(University of Hull)

Dec. 14 Non-Destructive Testing Group At the Institute's House, 6.30 p.m.
" *Some conductivity test methods and results* "
DR. R. W. POWELL, F.Inst.P.
(National Physical Laboratory, Teddington)

Reviews of Books

PHYSICS IN MY GENERATION

By Max Born

London : Pergamon Press Ltd. Pp. 232 + viii Price 40s.

Briefly and broadly, this book *is* the theoretical physics of the first half of the present century. Its glances are cast both fore and aft, but its aim is perfectly steady, namely to describe the transformation of the majestic subject of natural philosophy from a concept governed by mechanical models and deterministic laws to one expressible only in terms of probabilities and mathematical abstractions. The distinguished author achieves his purpose well nigh to perfection, by collecting together a number of his published papers dealing with the great themes of the period ; relativity, the quantum theory, statistical mechanics and so on. In addition, the reader is taken on the " grand tour," to meet in retrospect nearly all the great figures of the age, portrayed in kindly word-pictures, not omitting, however, their little foibles, and just occasionally, their surprising limitations.

Behind all this, however, lies a purpose, both deep and significant. It is that events have contrived to conduct so profound a scholar as Professor Max Born away from the belief that science *qua* science is always and inevitably superior to other (perhaps less clearly-cut) views of the world around us, to a position more nearly subjective, and, if the reviewer interprets these pages aright, not unsympathetic to a disciplined system of metaphysics. Leibnitz hoped that his scheme of universal semantics would help towards a healing of the nations of his day (because by using such a symbolic language properly it was impossible to make mistakes), but this has not in fact occurred. It seems that, on the contrary, in the conduct of our lives there must be an element of uncertainty—akin to Heisenberg's famous postulate—and that failure to acknowledge that limitation in all humility is to make experience too " brittle," and to risk an explosion.

Amongst the high-lights of philosophic import are the discussions of Bohr's principle of complementarity, and the nature of *Gestalten.* The latter the author would prefer to translate as " invariants," rather than as " shapes " or " forms." The present reviewer cannot resist observing that exactly such a connotation was explicitly contained in a free-energy problem formulated by him independently (1939) in quite a different context. The near-identity between " mathematical invariance " and " configuration " is evidently basic for both physics and psychology alike.

Faced with an assembly of essays such as this, it is perhaps graceless to ask for something " which is not on the table " ; nevertheless the request is going to be made, and it is this. Could we not have, perhaps in a second volume, if the writer would be generous enough to prepare it, a commentary upon Carathéordory's Axiomatic Thermodynamics which, if memory serves, is amongst the Professor's most enlightening compositions ? The sublime beauty of this particular use of Pfaff's equation is all too little known.

To a world engrossed in tensions of one kind or another, this book comes as a shaft of light, illuminating its recesses, and recalling it to its responsibilities to mankind.

F. I. G. RAWLINS

COMPUTERS : THEIR OPERATION AND APPLICATION

By E. C. Berkeley and L. Wainwright.

London : Chapman and Hall Ltd., New York : Reinhold Publishing Corporation. Pp. 336. Price 64s.

Most of the books that have been published recently on computing machinery have required of the reader an extensive knowledge of mathematics, physics and electronics. By comparison this book is written in a

lighter vein and is likely to appeal to the business executive rather than to the more technically-minded reader.

After an introductory chapter about mechanisms for handling information comes a general account of digital computers. Some analogue computing devices are then described and the relative merits of digital and analogue machines are discussed. Differential analysers, both mechanical and electronic, which represent the most highly-developed analogue machines are selected for detailed description, and there are shorter accounts of harmonic analysers and synthesizers.

After this, the reader is introduced to Simon, a miniature computer named after Simple Simon of Mother Goose because he is not a giant brain but a simple-minded one used for training and instruction. We then come to sterner stuff in the shape of Univac and its counterpart for scientific computing and the I.B.M. machines. From the descriptions of these machines we learn about their general design, capacities and speeds but there are few details of their construction. Finally, we enter the realm of speculation where the authors attempt to estimate the number of people likely to be displaced, and from what sort of jobs, by automatic computers. Present and potential applications are discussed at length with a view to helping probable buyers to determine where automatic calculation might be of value to them.

The book contains numerous lists of reference books, articles, and periodicals relating to existing automatic computers and of organizations where they and other computing services are available. It concludes with a glossary of terms and expressions from which, however, those commonly used when the machines go wrong have been omitted !

There is not a great deal in this book to attract the professional computer, but for those who are meeting the subject of automatic computation for the first time and who are more concerned with general ideas than with points of detail the book provides a pleasant introduction.

J. CRANK.

ANALYTICAL EXPERIMENTAL PHYSICS

By Professor M. Ference, Jr., Professor H. B. Lemon and Professor R. J. Stephenson

New York: University of Chicago Press, 1956. Pp. 623 + 1. Price £3.

The second revised edition of " Lemon and Ference " is more portable than what might be termed the First Folio, no less excellent in presentation, and rather more advanced in treatment. There has been a shift of emphasis towards the analytical side, achieved largely by curtailing the more elementary parts which were so thoroughly done before. The film-sequence photographs showing the progress of demonstration experiments have been discarded; I enjoyed these and found many of them helpful under the episcope, but although they gave cause for admiration they almost converted the book from its main purpose into a visual aid. Photographs are used fully in the present edition, but only where the message could not otherwise be conveyed adequately—as in diffraction patterns, thermodynamic surfaces, and pictures of modern apparatus and results.

The electricity and magnetism sections have been completely revised, in accordance with recent trends in teaching using MKS units; here it is very helpful to be reminded of the numerical values of μ_0 and ε_0 in each formula derived. The authors have treated atomic and nuclear physics in much greater detail, and there is a good outline of solid state physics. Recent applications and techniques, such as the scintillation counter and the bubble chamber, are included.

A new feature is a résumé at the end of every chapter—not a mere digest of its contents, but a list of the important points which should have been mastered. The mathematical treatment increases in severity as the book proceeds, on the assumption that the student will be following concurrently a course in the calculus.

The scope of the book covers the first year of a university course in the United States. It often happens that this means

a treatment which is perhaps wider than, but certainly not as deep as, the Advanced level courses to which we subject our schoolboys. But the present book is indeed an elementary university textbook, and a first-year undergraduate at a British university would find it helpful. It is, as the preface says, intended for the serious student who expects to continue in a career in the physical sciences—not an easy text but a challenging one. Two of the team of three distinguished authors have won awards for excellence in teaching, and the book bears all the evidence of enthusiasm and thoroughness in keeping with this. It can be highly recommended as a book to kindle and maintain the interest of the prospective physicist.

G. R. NOAKES.

ATOMS AND THE UNIVERSE

By G. O. Jones, J. Rotblat and G. J. Whitrow

London : Eyre & Spottiswoode. Pp. 254. Price 25s.

This book is based on a course of Extension Lectures to an audience some at least of whom had no previous scientific experience or training. In the passage from lecture notes to book form, it is difficult to avoid the conclusion that the treatment has become more demanding, not on account of any lack of clarity but because ideas are brought forward in a way which must surely have been cushioned by the processes of question and discussion in the original presentation. One sees the book as it now stands as by no means directed at the uninitiated, and accordingly no apology seems called for in recommending it most warmly to professional physicists.

The text falls into three parts : a first concerned with the elementary particles of physics, with nuclei, their reactions and energetics, and with the cosmic radiation, a second, shorter than the other two, dealing with the properties of bulk matter and the transition from classical to quantum physics, and a third devoted to astrophysics and cosmology. Although one may guess from external information as to the authorship of the various chapters, the continuity of style is notable, and in spite of the wide range of subject the book stands as a clear whole.

A great deal of the third section will be unfamiliar to many physicists while very many readers of the *Bulletin*, although not finding much that is new to them in the earlier parts, will certainly welcome the treatment as both pleasant and helpful.

The half-tone illustrations, particularly the astronomical photographs, are well chosen and admirably reproduced. This is a timely book and deserves to be a successful one.

J. G. WILSON.

Physical Society Meetings

Members of the Institute are invited to attend any of the following meetings of the Physical Society :—

Nov. 22	"*V Particles*" PROFESSOR G. D. ROCHESTER (University of Durham) and DR. C. C. BUTLER (Imperial College, London)	At Imperial College, 5 p.m.
Dec. 17, 18 and 19	Autumn Meeting "*Beta and Gamma-Ray Spectroscopy*"	At Edinburgh University

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE BOARD ON OCTOBER 2, 1956

An asterisk (*) indicates transfer from another grade

FELLOWS

*Abbott, Cyril Bernard, B.Sc., Ph.D., Principal Scientific Officer, Marine Biological Association, Plymouth.

Arreger, Constance Emma, M.Sc., Research and Development Engineer, Hilger & Watts Ltd., London.

*Dick, James Brownlee, B.Sc., M.A., Principal Scientific Officer, Building Research Station, Watford.

Mummery, Peter William, M.A., Principal Scientific Officer, U.K. Atomic Energy Authority, Harwell.

*Watts, Bernard Nelson, B.Sc., Head of General Physics Section, Research Laboratory, British Thomson-Houston Co. Ltd., Rugby.

ASSOCIATES

*Aston, Stanley Gordon George, B.Sc., Development Engineer, The General Electric Co. Ltd., Coventry.

Barritt, Kenneth Denny, B.Sc., A.R.C.S., Lecturer in Physics, Ewell County Technical College, Ewell, Surrey.

*Beazley, Kenneth Michael, M.Sc., Temporary Scientific Officer, Royal Naval Scientific Service, Portland.

Blitz, Jack, M.Sc., Assistant Lecturer, Acton Technical College, Acton.

*Boulding, Geoffrey Ramell, B.Sc., Senior Development Engineer, The General Electric Co. Ltd., Coventry.

Bullas, Derek Owen, B.Sc., Ph.D., Research Assistant, Middlesex Hospital Medical School, London.

*Burnside, William, B.Sc., Physicist, Research Department, Babcock & Wilcox Ltd., Renfrew.

*Carter, Philip Basil, B.Sc., Development Engineer, Standard Telephones & Cables Ltd., London.

*Close, Kenneth John, B.Sc., Lecturer in Physics, Nottingham & District Technical College, Nottingham.

*Coe, Roger Frank, M.Sc., Research Physicist, Joseph Lucas Ltd., Birmingham.

Colmer, Frederick Charles William, M.A., Development Engineer, Central Electricity Authority, London.

*Common, Thomas Charles, M.Sc., Physics Master, Royal Masonic Senior School, Bushey, Herts.

Davies, Robert Harding, M.A., B.Sc., Deputy Head, Atomic Power Department, The English Electric Co. Ltd., Leicester.

De, Manoranjan, M.Sc., Research Assistant, Physics Department, Imperial College, London.

Douglas, Alexander Shafto, B.A., Ph.D., Assistant Bursar, Trinity College, Cambridge.

*Gilbert, Joseph, B.Sc., Physicist, Westinghouse Brake & Signal Co. Ltd., London.

*Gray, Alan, M.Sc., Technical Service Officer, I.C.I. (A.N.Z.), Ltd., Melbourne, Australia.

*Haig, George Youngson, B.Sc., Physicist, Barr & Stroud Ltd., Glasgow.

Hall, Barbara Isabelle Herbert, B.Sc., Ph.D. Research Fellow, University of Adelaide, Australia.

*Harrison, Frederick William, B.Sc., Ph.D., Physicist, Mullard Research Laboratories, Surrey.

*Hoare, Peter William, B.Sc., Research Physicist, Marconi's Wireless Telegraph Co. Ltd., Chelmsford.

*Holbeche, Thomas Anthony, B.Sc., Ph.D., Scientific Officer, Royal Aircraft Establishment, Farnborough, Hants.

Jefferies, John Trevor, M.A., B.Sc., Research Officer, C.S.I.R.O., New South Wales, Australia.

*Johnson, Philip, B.Sc., Technical Officer, Imperial Chemical Industries Ltd., Stevenston, Ayrshire.

*Jones, Brian Ernest, B.Sc., Physicist, Medical Research Council, London.

*Kent, Thomas Brian, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Capenhurst.

Langton, William Arthur, B.Sc., Senior Physics Master, Liverpool Collegiate School, Liverpool.

Leck, John Henry, M.Eng., Lecturer, University of Liverpool.

*Leigh-Dugmore, Charles Henry, B.Sc., Manager, Fundamental Compounding Section, Dunlop Rubber Co. Ltd., Birmingham.

Legon, Walter James, B.Sc., Senior Science Master, Chester City Grammar School, Chester.

Moreley, John Godfrey, M.Sc., Senior Physicist, Pilkington Brothers Ltd., St. Helens, Lancashire.

Parks, George Henry, B.Sc., A.R.C.S., Deputy Head, Electronics Section, Siemens Brothers Co. Ltd., London.

*Pothecary, Ivan John William, B.Sc., Senior Scientific Officer, Meteorological Office, Air Ministry.

*Pringle, Kenneth, B.Sc., Instrumentation Engineer, Technological Department, Bataafsche Petroleum, Netherlands.

Secomb, David Arthur, B.A., B.Sc., Scientific Officer, Commonwealth Government, Department of Supply, Victoria, Australia.

*Stephens, Kenneth Gilbert, B.Sc., Ph.D., Research Physicist, Associated Electrical Industries Ltd., Aldermaston, Berkshire.

Taylor, Anthony Francis, B.Sc., Physicist, U.K. Atomic Energy Authority, Capenhurst.

*Taylor, Richard Gibson Strangman, B.A., M.Sc., Lecturer in Physics, University of Queensland, Australia.

Tracey, Robert John, B.Sc., Physicist, British Celanese Ltd., Derby.

*Walker, Paul Gordon, B.Sc., Research Officer, British Cotton Industry Research Association, Manchester.

Ward, Frank Lewis, B.Sc., Engineer, British Broadcasting Corporation, London.

Wartnaby, John, M.Sc., Assistant Keeper, Science Museum, London.

*Watts, James Wilfred, B.Sc., Chief Research Officer, R.A.F., Operational Research Branch, Singapore.

*Young, Alan Neal Durham, B.Sc., Assistant Technical Officer-Physicist, Imperial Chemical Industries Ltd., Stevenston, Ayrshire.

GRADUATES

Ainsworth, Brian, B.Sc., Research Physicist, Bleachers Association Ltd., Lancashire.

Angus, Robert Kennedy, B.Sc., Research Student, University of Oxford.

Baldwin, John Lewis Edwin, B.Sc., Electronic Engineer, Cinema-Television Ltd., London.

*Barron, David William, B.A., Research Student, Cavendish Laboratory, Cambridge.

Bozidar, Eric, B.Sc., Physicist and Chemist, British Celanese Ltd., Derby.

Bridge, Norman William, B.Sc., Graduate Apprentice, The English Electric Co. Ltd., Stafford.

Brightman, Francis Graham, B.Sc., Assistant Experimental Officer, U.K. Atomic Energy Authority, Cumberland.

Bunn, John Peter, B.Sc., Scientist, National Coal Board, Dudley, Worcs.

*Burrell, Laurence, B.Sc., Research Assistant, Westinghouse Brake & Signal Co. Ltd., London.

Chadney, Donovan Colin, B.Sc., Research Physicist, Research Laboratories, The General Electric Co. Ltd., Wembley.

Charlton, Colin, B.Sc., Technician, Armstrong Whitworth Ltd., Coventry.

Chatar, Singh Data, M.Sc., Research Student, Physics Department, University of Malaya.

Cheatham, James Alan, B.Sc., Physicist, Dunlop Rubber Co. Ltd., Birmingham.

Curtis, Roy Bernard, B.Sc., Assistant Master, Grammar School for Boys, Bromley, Kent.

Demetsopoullos, Loamis Christon, B.Sc., Research Assistant, Borough Polytechnic London.

Donegan, Daniel Patrick, Experimental Officer, Ministry of Supply, Salisbury.

Dorrington, Brian George, B.Sc., Assistant Technical Officer, Research Department, Imperial Chemical Industries Ltd., Stevenston, Ayrshire.

Gallehawk, John Charles, B.Sc., Physicist, Nuclear Power Plant Co. Ltd.

Grimes, Norman William, B.Sc., Research Student, University of Bristol.

Hale, Kenneth Frank, B.Sc., Assistant Experimental Officer, D.S.I.R., Teddington, Middlesex.

Henderson, John Fergus, B.Sc., Technical Engineer, Bristol Aero Engines Ltd., Filton.

Higgins, Alan John, B.Sc., Research Engineer, Carborundum Co. Ltd., Manchester.

Higham, Anthony Dent, B.Sc., Junior Engineer, E.M.I.E.D.

Hood, Iain Gibson, B.Sc., Research & Development Engineer, Sperry Gyroscope Co. Ltd., Feltham, Middlesex.

Johnson, John, B.Sc., Research Student, University of Exeter.

Kennett, Anthony William Colin, B.Sc., Student, University of Reading.

Killean, Reginald Cameron Gordon, B.Sc., Senior Physics Master, Embley Park School, Hants.

*Kirk, Michael Tayler, B.Sc., Research Assistant, Associated Electrical Industries Ltd., Aldermaston, Berkshire.

Knight, Richard Bryan Douglas, M.A., D.Phil., Technical Officer, Imperial Chemical Industries Ltd., London.

Kosky, Julius, B.Sc., A.R.C.S., Physicist, Repeater Research Laboratory, Submarine Cables Ltd., Greenwich.

Lackey, Dennis, B.Sc., Assistant Technical Officer, Imperial Chemical Industries Ltd., Manchester.

McGhee, John, B.Sc., Experimental Officer, U.K. Atomic Energy Authority, Cumberland.

McLaughlan, Derek John Alexander, B.Sc., Technical Engineer, Bristol Aircraft Ltd., Bristol.

Manning, Geoffrey Anthony, B.Sc., Scientific Staff, The General Electric Co. Ltd., Stanmore, Middlesex.

*Pounder, Bede, B.Sc., Physicist, The Plessey Co. Ltd., Swindon, Wilts.

Powell, John, B.Sc., Research & Development Engineer, Cable & Wireless Ltd., London.

Robbins, Maurice Alfred, B.Sc., Chief Physicist, Alkaline Batteries Ltd., Worcester.

Robinson, Kenneth Buckley, B.Sc., Physicist, British Thomson-Houston Co. Ltd., Middlesex.

Ryder, Raymond Victor, B.Sc., Dunlop Research Centre, Birmingham.

Simmons, Brian Alec William, B.Sc., Research Student, University of Southampton.

*Spencer, John Brian, B.Sc., Research Investigator, Mond Nickel Co. Ltd., Birmingham.

Sprackling, Michael Thomas, B.Sc., Research Student, University of Bristol.

Subett, Salwa Katherine, B.Sc., Research Physicist, Christie Hospital, Holt Radium Institute, Manchester.

*Thomas, Robert John, B.Sc., Junior Research Assistant, Electrical Research Association, Perivale, Middlesex.

Thompson, Kenneth, B.Sc., Research Student, University of Durham.

*Wenham, David George, Junior Technician, Royal Air Force.

Young, Christopher Patrick, B.Sc., Assistant Experimental Officer, D.S.I.R., London.

8 Students and 5 Subscribers were also admitted.

The Institute's Journals

PRINCIPAL CONTENTS OF THE NOVEMBER, 1956, ISSUES

Journal of Scientific Instruments: Volume 33, No. 11

PAPERS

An automatic electromechanical stressing unit for creep and fatigue testing. By A. J. Kennedy, F.Inst.P., and R. F. Slade (*The British Iron and Steel Research Association, London, S.W.11*).

The apparatus is designed to apply a complex creep and fatigue stressing programme to a metal test-piece. A new electrical system has been developed which controls the extension of a mechanical spring in such a way that the test proceeds automatically under either constant stress or constant load, as required. The creep strain and the stress error are recorded during the test. The same system may be used to conduct creep recovery or stress relaxation tests.

An electrostatic null detector. By J. Hart, A.Inst.P., and A. G. Mungall (*Division of Applied Physics, National Research Council, Ottawa, Canada*).

A simple, inexpensive and rugged electrostatic null detector for use in very high resistance bridge circuits is described. The detector has a sensitivity better than 0·5 V and has been used for potential measurements from 0 to 1,000 V. It has a capacity of about 3 pF.

An electrical indicator for a mercury U-tube manometer. By A. E. Hawkins, A.Inst.P. (*Department of Physiology, Royal Veterinary College, University of London*).

The metal limbs of a U-tube act as outer conductors of two cylindrical capacitors. The tubes are coated internally with a thin layer of a dielectric material. The mercury acts as a variable inner conductor. The system can be made very sensitive and has a general scatter of less than ± 1 mm of mercury.

Eight-channel recording on ¼ in. magnetic tape with a stationary-tape playback. By J. C. Barton (*University College of the West Indies, Jamaica, B.W.I.*).

A method of constructing multi-channel magnetic heads is described and their performance reported. The problem of interference between channels is discussed and details given of a new technique for reducing this interference. The playback equipment consists of an eight-channel head mounted on an electrically maintained tuning fork so that it picks up signals from a stationary tape. Signals from each channel are switched electrically in time succession and, after amplification, displayed simultaneously on an oscilloscope. It is possible to resolve pulses recorded along the tape at a separation of 0·1 mm. Precautions necessary for observing very small signals are discussed.

Simple equipment for a small low temperature laboratory. By R. F. Broom and A. C. Rose-Innes (*Services Electronics Research Laboratory, Baldock, Herts*).

Until recently low temperature research has been chiefly carried out in those laboratories having the complicated apparatus needed to liquify hydrogen or helium. It has now become possible to buy liquid helium from the National Physical Laboratory and this paper describes simple and versatile low temperature equipment designed to use this helium. The temperature range in which experiments can be carried out is from 1·3 to 33° K. This paper is intended for those not already familiar with low temperature techniques.

An instrument for the measurement of salinity in estuaries. By E. G. Sandels (*Hydraulics Research Station, Howbery Park, Wallingford, Berks*).

The instrument described was designed for salinity measurements in estuaries. It is carried in a boat, water being pumped through it from an intake which is lowered into the estuary. Electrical conductivity and temperature are measured and the salinity is computed readily from a nomogram. Radio-frequency circuits are employed for the measurements, the indicator being a milliammeter operated from a d.c. amplifier. The accuracy is better than ± ½ parts per thousand over a salinity range of from 0·2 to 50 p.p.t.

A fast coincidence system for the measurement of short lifetimes. By G. Jones and Prof. J. B. Warren, F.Inst.P. (*Physics*

Department, University of British Columbia, Vancouver, Canada).

Details are given of a fast coincidence system comparable to that developed by Bell, Graham and Petch, but employing the scheme of Neilson and James in which the time separation of associated events is converted to pulse amplitude and sorted on a conventional kicksorter. In this manner the whole coincidence resolution curve is obtained at one time while retaining an inherent time resolution of about 2×10^{-10} s.

Dynamometer for tensile testing of high polymers. By A. R. Payne, Grad.Inst.P., and J. F. Smith (*Research Association of British Rubber Manufacturers, Shawbury, Shrewsbury, Shropshire*).

The instrument described in this paper for measuring static and dynamic stresses is a new type of dynamometer that has been found useful, especially in tensile testing of high polymers. This dynamometer measures force by the deformation of a proof ring. Load range and sensitivity can be changed instantaneously by adjusting an attenuator in the electronic circuit; this obviates the necessity for stopping the test and changing the pendulum weight of the conventional test machine, and also gives a much greater range of loads. A fine gain control on the amplifier driving the recorder can be calibrated in terms of specimen thickness, which in conjunction with special scales for use on the recorder chart, makes the instrument record stresses directly in pounds per square inch.

Frictional and inertia effects, which occur only in the recorder, are considerably reduced, and if a cathode ray-oscillograph is used instead of the recorder, friction and inertia are virtually eliminated and rapid force changes can be followed.

The new dynamometer is robust in design, linear in response to force, and easily adaptable to all present-day types of rubber tensile testing machine. Preliminary tests show that the new instrument gives more reproducible results in tensile tests on rubber than do pendulum machines.

An electronic analogue of the saturated vapour pressure curve of water. By R. J. Taylor, A.Inst.P. (*Division of Meteorological Physics, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia*).

An analogue of the saturated vapour pressure curve of water between 0 and 30° C which is suitable for inclusion in a complete electrical simulation of the psychrometric equation is described. The stated range of temperature can be covered in three sub-ranges of ten centigrade degrees, each with an accuracy in vapour pressure of a fraction of 1%. A theoretical analysis indicates that the slope of the curve, which is important in certain applications, is reproduced with 2% accuracy.

An all-glass reference electrode for molten salt systems. By J. O'M. Bockris, G. J. Hills, D. Inman and L. Young, (*Imperial College of Science and Technology, London, S.W.7*).

The construction and performance is described of a glass electrode generally applicable to molten salt systems up to 550° C.

A heart pulse amplifier and ratemeter. By D. G. Wyatt (*The Nuffield Institute for Medical Research, University of Oxford*).

A pulse amplifier and ratemeter for measuring heart rate are described. The self-biasing arrangement which is used in the amplifier greatly reduces the effects of changes in the mean level, shape, amplitude and duty cycle of the pulse. The ratemeter has rapid response and is suitable for continuous recording.

LABORATORY AND WORKSHOP NOTES

NOTES AND NEWS

NEW BOOKS

NEW INSTRUMENTS, MATERIALS AND TOOLS

NOTES AND COMMENTS

British Journal of Applied Physics: Volume 7, No. 11

SPECIAL ARTICLE

Summarized proceedings of a conference on the structures of semi-crystalline and non-crystalline materials — London, November, 1955.

The annual Autumn Conference of the X-ray Analysis Group of The Institute of Physics was held in London on November 18 and 19, 1955. The three sessions dealt respectively with coals, cokes and carbons; with glasses, liquids and disordered structures; and with non-biological fibres.

PAPERS

The suppression of screen grid emission by carbon. By J. A. Champion, Grad.Inst.P. (*M.-O. Valve Co. Ltd., at the G.E.C. Research Laboratories, Wembley*).

The screen grid emission level which obtains in a receiving valve in which there is no suppression is shown to be of the same magnitude as that of a thin activated layer of barium oxide. It is further shown that the mechanism by which carbon suppresses screen grid emission is by the chemical reduction of deposited barium oxide to barium which evaporates. Below 900° C this reduction proceeds at a negligible rate and is only sufficient to activate the grid film. At 950° C the emission decays to a negligibly small value after a few minutes.

Multiplicity in the anode marks of sparks.

By J. M. Somerville, F.Inst.P., and C. T. Grainger (*The University of New England, Armidale, New South Wales, Australia*).

The conditions which lead to multiplicity in the mark left on the anode by a spark of short duration in air have been studied. The anode surface condition is important in determining multiplicity and was controlled in this investigation by depositing various numbers of layers of barium stearate on clean palladium, aluminium and tin anodes. The nature of the mark is determined in the first few tenths of a microsecond of the life of the spark and depends chiefly on the number of " contaminating " layers on the anode, on the rate of rise of current in the spark and on the breakdown voltage of the spark gap.

The frequency of vibration and the elastic stability of a fixed-free strip.

By R. F. S. Hearmon, F.Inst.P. (*Forest Products Research Laboratory, Princes Risborough, Bucks*).

The suggestion that critical buckling loads can be found by estimating the load at which the frequency of vibration becomes zero is subjected to experimental test on fixed-free strips of boxwood, brass and steel. The results show good agreement between the load at zero frequency and the critical load calculated from the Euler formula.

The fusing of wires with heavy surge currents.

By A. E. Barrington (*Queen Mary College, University of London*).

The behaviour of wires fused by means of a high-frequency discharge yielding peak-current densities of 100-200 kA/mm² is investigated. From records of electrical transients it is estimated that complete melting does not occur prior to break-up. The nature of the arc discharge following break-up is shown to depend on the length and the material of the wires when exploded in air, but independent of these when exploded in vacuum. As a consequence of these experiments, results obtained by earlier investigators are examined critically.

The electric strength of hydrocarbon gases.

By A. E. D. Heylen and T. J. Lewis (*Department of Electrical Engineering, Queen Mary College, London*).

Careful measurements of the static electric strengths of a number of pure hydrocarbon gases over a range of pressure and spark-gap spacings, including the Paschen minimum, are reported. A relationship between strength and molecular structure is found which, if unsaturated compounds such as ethylene, acetylene and butadiene are included, is not so simple as hitherto reported. The possible correlation of electric strength with the ultra-violet spectra and Ramsauer cross-sections of these gases is discussed briefly.

Pulse discharges which occur readily in these gases at fields below the breakdown value are attributed to the exceedingly small secondary ionization coefficients (γ).

Reduction of counting time in low activity assays.

By H. A. Hughes, A.Inst.P. (*Physics Department, Western General Hospital, Edinburgh, 4*).

Modification of a counting system can result in a reduction in background and sample counting rates. Such an arrangement will decrease the minimum counting time necessary to achieve a given fractional deviation in the net counting rate only under certain conditions. A method is described of determining these conditions. The application of this principle is exemplified in the use of a pulse amplitude analyser with a scintillation counter.

The tensile strengths of viscous liquids under dynamic loading.

By T. H. Bull (*Imperial Chemical Industries Ltd., Akers Research Laboratories, Welwyn, Herts*).

Under similar conditions of transient loading the cavitation thresholds of syrup and olive oil are 130×10^6 dyne/cm² and 29×10^6 dyne/cm² respectively. For fluids with a viscosity (η) in the range 0·01 to 400 P the cavitation threshold pressure P_c is given by the empirical relation $P_c = k\eta^{0.2}$. This result can be interpreted on the basis of the growth of cavitation nuclei in viscous fluids subjected to transient stresses.

NOTES AND CORRESPONDENCE

A photoelastic method of two-dimensional separation of stresses along a line of symmetry by using the isochromatic fringes only.

From P. D. Flynn, R. Guernsey *and* S. P. Christodoulides.

Ring conduction in the early stages of sparks.

From J. M. Somerville *and* N. H. Fletcher.